CMPE 124 Lab 6: A 4-bit Adder and Subtractor Circuit

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***Abstract*—The purpose of this lab project is to implement a 4-bit adder and subtractor circuit with the help of our previously implemented 74LS163 counter.**

I. Introduction

This lab project is based on the implementation of a 74LS163 counter, a logical circuit that tracks time by using 8 bits.
We use this counter's input to count from 0 to 15 and add to or subtract from these values using a constant 4-bit number, generated with 4 binary switches.

II. Design Methodology

For this lab project, we use the 74LS163 4-bit counter. This 4-bits counter requires not only a voltage source—to function—and a clock—to provide it with time input—but also a binary switch, to reset it and ensure the wave functions it outputs are correct. Additionally, although we use a resistor, its value can be changed or ignored; our 1kΩ resistor is part of the circuit to demonstrate that we are not focusing on the input voltage, but on the H and L states instead.
Furthermore, we create a constant 4-bit number by implementing 4 binary switches, and we then implement a circuit to have this number added to or subtracted from the counter's variable values. Finally, we verify our circuit's functionality with two hex displays, one connected to our counter and another to the circuits' results.

A. Parts List

- Clock
- 5V source
- A 74LS163 counters
- Binary switches
- Resistor
- AND gates
- OR gates
- XOR gates
- Hex displays

B. Truth Tables

State	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
q_0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
q_1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
q_2	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
q_3	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

Figure 1. Truth table for a 74LS163 4-bit counter.

C. Schematics

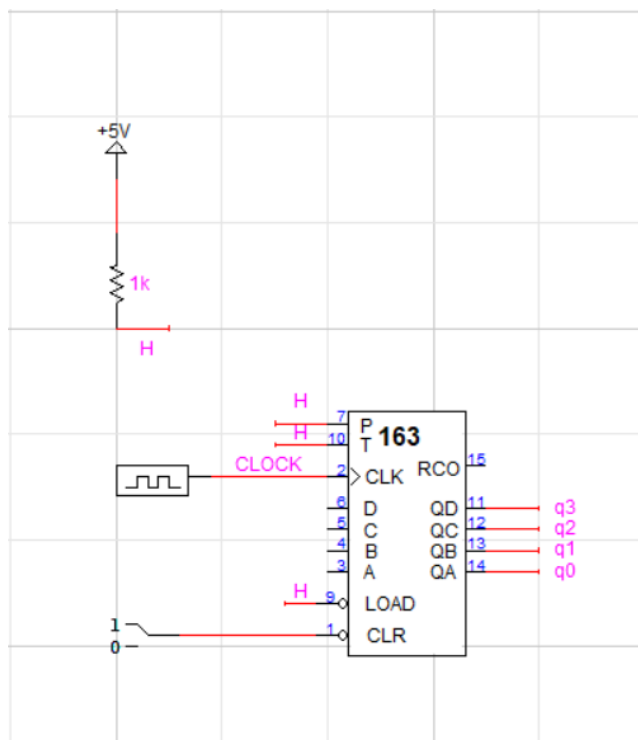

Figure 2. 74LS163 clock-counter circuit scheme.

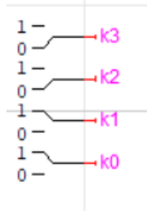

Figure 3. Setting the switches to encode for the decimal number 3.

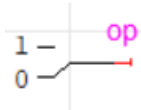

Figure 4. Binary switch that encodes for the arithmetic operation. 0 encodes for adding, 1 for subtracting. op stands for "operation".

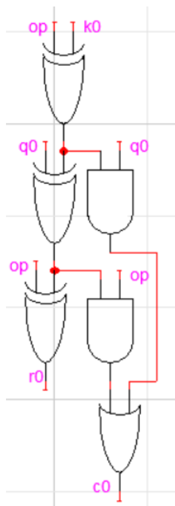

Figure 5. Adder and subtractor branch for k0 and q0—the LSBs for the group of binary switches and the counter, respectively. r0 stands for "result 0", and c0 for "carry 0."

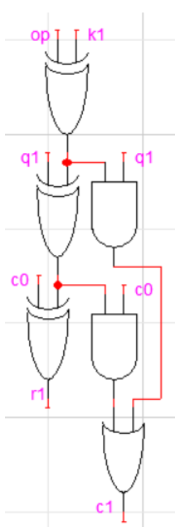

Figure 6. Adder and subtractor branch for k1 and q1—the second LSBs for the group of binary switches and the counter, respectively. Notice how "carry 0" is used as input.

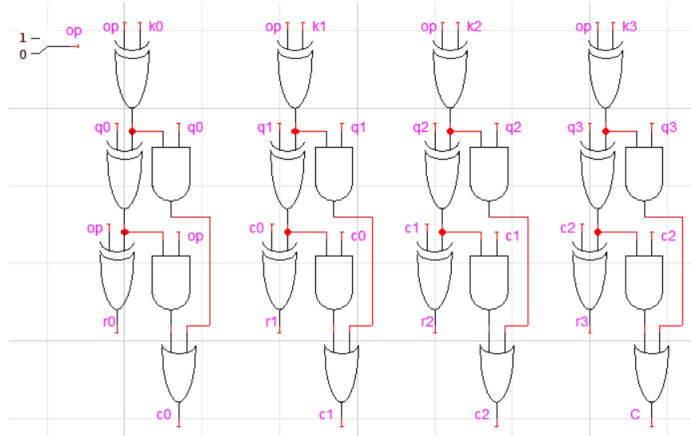

Figure 7. Adder and subtractor circuit. C stands for "carry out."

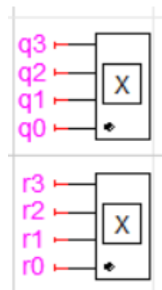

Figure 8. Two hex displays, one connected to the counter and the other to the adder and subtractor circuit's output.

III. TESTING PROCEDURES

1. Create a counter as pictured in Figure 2.
2. Set up the binary switches as pictured in Figure 3 and 4.
3. Set up the logic gates and their input as pictured in Figures 5, 6, and 7.
4. Set up the testing circuit, as pictured in Figure 8.
5. Reset the clock with a switch and run the simulation.

IV. TESTING RESULTS

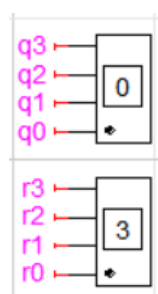

Figure 9. Testing circuit when the counter's value is the decimal number 0, and the counter is set to add.

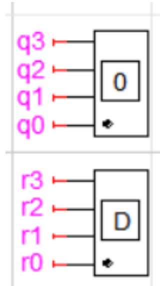

Figure 10. Testing circuit when the counter's value is the decimal number 0, and the counter is set to subtract.

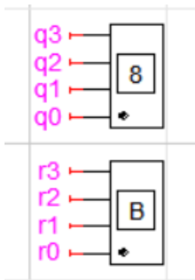

Figure 11. Testing circuit when the counter's value is the decimal number 8, and the counter is set to add.

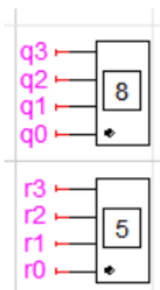

Figure 12. Testing circuit when the counter's value is the decimal number 8, and the counter is set to subtract.

V. Conclusion

In conclusion, a 4-bit binary number can be represented by a 74LS163 clock-counter circuit, as well as four binary switches. We can process these binary values via logic gates—just like we did in our previous labs—and create a circuit that takes the switches' constant value and adds it to or subtracts it from the counter's value. By implementing this adder and subtractor circuit, we've come a step closer to learning about some of the most fundamental parts of computers, like arithmetic logic units in this case—just like in our previous lab, which involved comparing two binary numbers.